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2.	Patent application number *(The Patent Office will fill this part in)*	0401389.2
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	Remtons Limited, 5 Crosfields Close, Reading, Berkshire RG2 9AY, United Kingdom.
	Patents ADP number *(if you know it)*	8773291001
	If the applicant is a corporate body, give the country/state of its incorporation	
4.	Title of the invention	Illumination Method and Apparatus
5.	Name of your agent *(if you have one)*	Forrester Ketley & Co.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Forrester House 52 Bounds Green Road London N11 2EY
	Patents ADP number *(if you know it)*	133001

		Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
6.	Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months.			

		Number of earlier UK application	Date of filing *(day / month / year)*
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8. Is a Patents Form 7/77 (Statement of inventorship and of right to grant of a patent) required in support of this request? — Yes

Answer YES if:
a) any applicant named in part 3 is not an inventor, or
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Continuation sheets of this form	
Description	9
Claim(s)	3
Abstract	
Drawing(s)	2 + 2

10. If you are also filing any of the following, state how many against each item.

Priority documents	
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Statement of inventorship and right to grant of a patent (Patents Form 7/77)	
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Signature(s) Forrester Ketley & Co. Forrester Ketley & Co

Date 22 January, 2004

12. Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom

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Title: "Illumination method and Apparatus"

THIS INVENTION relates to microwave, millimetre wave or infrared imaging system, such as, for example, the systems proposed by the inventor in WO03/012524 or WO03/075554.

Passive mm-wave imaging has the potential for detecting concealed weapons because clothing is in general transparent and metal objects have a high reflectivity (~100%), particularly when compared with the reflectivity of skin which is of the order of 50%.

Clouds are largely transparent and the sky temperature is close to that of liquid nitrogen (100K). Highly reflective objects tend to reflect this cold sky while highly emissive objects radiate at their black body temperature (~300K). Thus there is a 200K temperature difference between apparent temperature of a highly reflective surface and a highly emissive surface.

This difference in apparent temperature provides a contrast in a mm-wave image, which can be used to detect concealed metal and dielectric objects.

Frequently observers would like to detect concealed weapons on a person when that person is inside a building or in a confined space where cold sky reflections are not possible or are restricted and where ambient illumination of the subject being scanned is provided by surfaces which may be at a temperature much closer to, or even higher than, say, the body temperature of a human subject being scanned, so that contrast in the resulting image is much reduced.

It is an object of the present invention to provide a solution to the above-noted problem.

According to one aspect of the invention, there is provided a method of illuminating subjects to be imaged by a microwave, millimetre wave or infrared passive imaging system, comprising directing, onto the subject to be imaged, the image or shadow, as here defined, of a cold source, i.e. a source with a low black body temperature, or of a hot source, i.e. a source with a black body temperature significantly higher than that of the subject to be imaged.

According to another aspect of the invention there is provided imaging apparatus for passive microwave, millimetre wave or infrared imaging, including a receiver for microwave, millimetre wave or infrared radiation from the scene or subject being imaged, directing means for directing such radiation onto the receiver, a cold source or a hot source, i.e. a source with a low or high black body temperature, and means for directing the image or shadow, as herein defined, of said cold source or hot source onto the scene or subject being imaged.

In operation of the invention using a cold source, the cold source can be thought of as directing "cold" radiation onto the subject from the cold source, although from another point of view, the cold source is effectively absorbing radiation emanating from the subject, without re-emitting that radiation, with the result that radiation emanating from the imaging apparatus, or from objects close to the latter, and reflected (e.g. by metal items carried by the subject) back towards the imaging apparatus, is much reduced, as compared with what would be the case if the apparent black body temperature of the imaging device corresponded to the room temperature in the building where the imaging is being carried out, so that contrast in the image is significantly improved.

Arrangements in which contrast is improved in this way are herein referred to, for convenience, as arrangements in which the image or shadow the cold source is directed to the subject or scene by being scanned.

Alternatively, it would be possible, in accordance with the present invention, to use instead of the cold source, a hot source, i.e. an emissive body with a temperature significantly higher than the body temperature of the subject being scanned, and in which radiation from the hot source is directed onto the subject being scanned, to be substantially absorbed by, for example, the clothing and skin of the subject but to be reflected from metal objects carried on the body of the subject, such as concealed weapons etc., thereby again increasing contrast, (although in this case, of course, the metal objects will appear as being brighter, rather than darker, than the other parts of the subject in the resulting image). In a preferred embodiment of the invention, a cold source is used comprising a emissive body, e.g. a metal block or panel with a black surface, the block or panel being artificially cooled, e.g. by liquid nitrogen. Thus, in this alternative arrangement it is convenient to regard the image of the hot source as being directed onto the subject or scene being scanned.

An embodiment of the invention is described below with reference to the accompanying drawing in which:-

Figure 1 is a diagrammatic side view of a receiver arrangement in a scanning apparatus according to the invention.

Figure 2 is a view, similar to Figure 1, of a (preferred) variant,

Figure 3 is a schematic plan view of an illuminating and imaging arrangement embodying the invention in another of its aspects,

Figure 4 is a diagrammatic perspective view of a cube corner reflector, and

Figure 5 is an elevation view of an array of cube corner reflectors.

The receiver arrangement shown in Figure 1 may be used as the radiation receiver or sensor in a scanning imaging apparatus of the kind described in WO03/012524 or WO03/075554, or where such scanning apparatus includes an array of radiation sensors or receivers, each of these may be of the form illustrated in Figure 1.

Referring to Figure 1, the receiver arrangement may comprise a radiation receiver or detector proper 10, fed by a horn 12 into which radiation received from the scene or subject being scanned by the scanning apparatus is directed. Disposed in the path of such radiation and preferably, as illustrated, in the horn 12, is a beam splitter 14, set an angle with respect of the major axis of the horn, i.e. at an angle to the direction of incoming radiation, so as to reflect a portion of such radiation laterally from the horn, (e.g. via an aperture or radiation-transparent window in the side of the latter), to a cold source 16, the beam splitter 14 allowing the remainder of the incoming radiation to pass to the receiver 10. The cold source may, for example, comprise a metal block of plate presenting an emissive, e.g. matt black, surface towards the beam splitter and which metal block or plate is artificially cooled, e.g. by liquid nitrogen. As a result, microwave, millimetre wave or infrared radiation reflected onto the source 16 is largely absorbed and very little is re-emitted towards the beam splitter 14, with the result that the black body radiation emitted towards the subject being imaged by the receiver 10 and source 16 in combination is significantly reduced as compared with the case in which the beam splitter 16 is omitted and/or the source 16 is at ambient temperature, so that reflection of such radiation, back towards the scanning apparatus by, for example, reflective, e.g. metal, items carried by the subject is much reduced and such items appear largely "black" in the resulting image, in contrast to, e.g. areas of flesh or skin.

In a more refined variant, illustrated in Figure 2 and of particular utility where the receiver 10 is, as is generally the case at the wavelengths in question, sensitive to radiation plane polarised in a particular direction, the simple beam splitter 14 may be replaced by a wire grid polariser 14a and a quarter wave transmitter or reflector 17, or alternatively a ferrite element configured as a Faraday rotator 17, may be mounted in the path of the radiation between the wire grid polariser and the subject, e.g. in the horn 12 as illustrated in Figure 2. The cold source 16 may be replaced by a hot source, i.e. an emissive body with a temperature significantly higher than the temperature of the body being scanned or of the bodies in the scene being scanned. ~~[So that advantages ?] consider the case of a high temperature source ?~~

As indicated above, microwave, mm-wave and infrared imaging works well in the open when objects are able to reflect the cold sky. The imaging apparatus used in such imaging detects changes in reflectivity from point to point in the scene imaged. This situation is analogous to visible-light imaging on a bright cloudy day, except that in visible-light imaging a reflective surface may reflect radiation from the sun, while in mm-wave imaging, for example, a reflective surface in the open is likely to reflect the lack of radiation from the cold sky.

Inside a building it may be necessary to use artificial illumination for mm-wave cameras as for visible light imaging. In visible-light imaging it may be sufficient to use a single source of radiation since most surfaces of interest scatter the incident radiation. In the mm-wave region however objects in a scene being imaged tend to be more specularly reflecting, so that radiation from an illumination source does not necessarily reflect towards a mm-wave camera.

It is an object of the present invention, in further aspects, to provide an illuminating method and an illuminating and imaging apparatus by which the last-noted disadvantage may be avoided or mitigated.

It is a further object of the invention to provide an artificial environment within which active illumination from a hot or cold source is made to reflect from an object towards a mm-wave, microwave or infrared camera.

Referring to Figure 3 of the accompanying drawings, which is a schematic plan view of illuminating and imaging arrangement embodying the further aspects of the invention, a mm-wave imaging device 100, which may be a scanning apparatus as described in WO03/012524 or WO03/075554 is arranged facing the object or target 102 to be imaged. The apparatus is arranged to direct a beam of radiation to which the imaging device 100 is sensitive from an active illumination radiation source (not shown) onto the object and the imaging device is arranged to receive such radiation reflected from the object. As shown in Figure 3, the radiation from the radiation source is bore sighted with the direction of view of the millimetre wave camera 100. That is to say, the arrangement is such that the radiation from the source is directed onto the object or target 102 substantially along the line of sight of the imaging device or camera 100. In the absence of the cube-corner reflective structure 104 referred to below, (and assuming the imaging device or camera 100 to be of the scanning type so that, at any given instant, only a relatively small elementary part of the overall field of view defined by the scanning raster is providing input to a particular (or even the sole) radiation receiver in the imaging device), if the corresponding portion of the target being illuminated reflects the radiation back to the camera/imaging device 100 in such a way that the radiation reaches the radiation receiver, then that elementary part of the

field of view will be observed well. However, if the corresponding part of the target 102 being illuminated reflects the radiation at an angle so that the reflected radiation misses the radiation receiver 100, then the corresponding part of the object or target will appear not to be illuminated. Referring again to Figure 3, this illustrates the situation where cube corner reflectors 104 are provided. Thus, Figure 3 shows a situation in which radiation from the active illumination source mounted within the camera/imaging device 100 is directed onto a spot on the target 102 in a beam and is reflected at an oblique angle from that spot towards the reflective structure 104. This structure reflects the radiation incident upon it back towards the originally illuminated spot on the target, from which it is reflected back again to the camera/imaging device 100, to be detected.

The reflective structure 104 may consist of an array of corner-cubes, otherwise known as a retro-reflectors. A reflective corner-cube, that is to say a reflector comprising three mutually perpendicular planar faces P,Q and R which meet (from the point of view of radiation entering the reflector) in an internal corner having the same configuration as the internal corner of a hollow cube, (as shown in Figure 4), has the property that a ray of radiation reflected by the corner-cube reflector is parallel to the direction of the incident ray before such reflection, but is laterally displaced from it. An array of congruent corner-cubes, as illustrated in Figure 5, has the same property but the lateral displacement of the reflected ray with respect to the incident ray is still determined by the dimensions of the individual corner-cubes in the array and not by the size of the array as such. The lateral displacement referred to above can effectively be eliminated if the size of each corner cube is comparable with or smaller than the diffraction limited spot size at the structure.

Where the imaging device 100 is of the scanning type, in which radiation from a relatively extended field of view is scanned raster-fashion into a stationary radiation receiver or linear array of stationary receivers as described with reference to the apparatus of Figures 1 to 6 or as described in WO03/012524, then, reciprocally, radiation from a radiation source located, (or apparently located), at the receiver can conversely be scanned, by the same operation of the scanning apparatus, over the object to be imaged, so that, at any instant, the part of the image being illuminated can also be the part being "viewed" by the receiver. It will be appreciated that such an arrangement may be realised by using a beam splitter or the like arrangement which may be employed to bring the path of the beam from the illumination source, and the line of sight of the radiation receiver, into alignment. Although such an arrangement is not essential, it does make it possible to illuminate only the portion of the object being imaged at the respective instant. This reduces the power requirement for the illumination source and/or reduces the number illumination sources required. In arrangements in which the scanning apparatus in the imaging device feeds two or more radiation receivers simultaneously, (so that each radiation receiver contributes a respective sub-raster to the overall scan), a respective illumination source maybe associated with each radiation receiver, in the manner described above.

When used in this specification and claims, the terms "comprises" and "comprising" and variations thereof mean that the specified features, steps or integers are included. The terms are not to be interpreted to exclude the presence of other features, steps or components.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS

1. A method of eliminating subjects to be imaged by a microwave, millimetre wave or infrared passive imaging system, comprising directing onto the subject to be imaged, the image or shadow, as herein defined, of a cold source, i.e. a source with a low black body temperature, or of a hot source, i.e. a source with a black body temperature significantly higher than that of the subject to be imaged.

2. A method according to Claim 1 wherein said cold source or hot source is incorporated in said imaging system and uses at least part of the imaging system which is adapted to receive imaging radiation from the scene or subject being imaged to direct said image or shadow of the cold or hot source onto the scene or subject being imaged.

3. Imaging apparatus for passive microwave, millimetre wave or infrared imaging, including a receiver for microwave, millimetre wave or infrared radiation from the scene or subject being imaged, directing means for directing such radiation onto the receiver, a cold source or a hot source, i.e. a source with a low or high black body temperature, and means for directing the image or shadow, as herein defined, of said cold source or hot source onto the scene or subject being imaged.

4. Apparatus according to Claim 3 wherein said directing means for directing radiation from the source or subject being imaged onto said receiver forms, at least in part, part of said means for directing said image or shadow from said cold source or hot source.

5. Apparatus according to Claim 4 wherein said image or shadow of said cold source or hot source is directed onto the scene or subject being imaged, and radiation from said scene or image is directed onto said receiver, via a conventional circulator, or via a wire grid polariser and quarter wave reflector or transmitter in combination, or via a wire grid polariser and a Faraday rotator.

6. A method of illuminating subjects to be imaged by a microwave, millimetre wave or infrared passive imaging system, substantially as hereinbefore described, with reference to Figure 1 or Figure 2 of the accompanying drawings.

7. Apparatus according to Claim 3 and substantially as hereinbefore described with reference to Figure 1 or Figure 2 of the accompanying drawings.

8. A method of illuminating an object by radiation in the microwave, millimetre wave or infrared ranges for imaging by an imaging device, comprising arranging a cube-corner reflective array facing the object and disposed laterally with respect of the line of sight between the object and the imaging device and directing such radiation onto the object, from a radiation source, along a path corresponding to or close to said line of sight, whereby light from said source, reflected laterally from the object, will be reflected, in turn, by the cube-corner array, back substantially along the path which it followed from the object to the cube-corner array, to be reflected in turn, by the object, back to the imaging device.

9. A method according to Claim 8 wherein the imaging device is arranged to scan the object in a scanning raster and wherein the radiation from said source is directed onto the object in a beam which is caused to scan the object in a corresponding scanning raster such that the instantaneous path of the beam of said radiation from said source to the object corresponds substantially to the instantaneous line of sight from the imaging device to the object.

10. Apparatus for illuminating and imaging an object in an object area by radiation in the microwave, millimetre wave or infrared ranges, comprising an imaging device, a source of such radiation, a cube-corner reflective array arranged facing said object area and means for directing such radiation from the radiation source towards said object area along a path corresponding to the line of sight of the imaging device.

11. Apparatus according to Claim 10 wherein the imaging device is arranged to scan the object area in a scanning raster and said means for directing is arranged to direct a beam of such radiation, from said source, towards the object area and to scan the beam in corresponding raster over the object area, such that the instantaneous path of the beam of said radiation from said source to the object area corresponds substantially to the instantaneous light of sight from the imaging device to the object area.

12. A method according to Claim 8 and substantially as hereinbefore described with reference to Figures 3 to 5 of the accompanying drawings.

13. Apparatus according to Claim 10 and substantially as hereinbefore described with reference to and as shown in Figures 3 to 5 of the accompanying drawings.

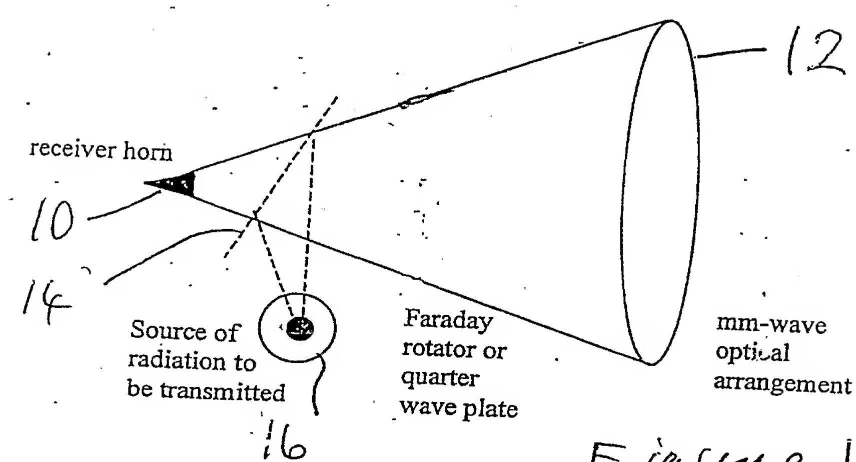


Figure 1

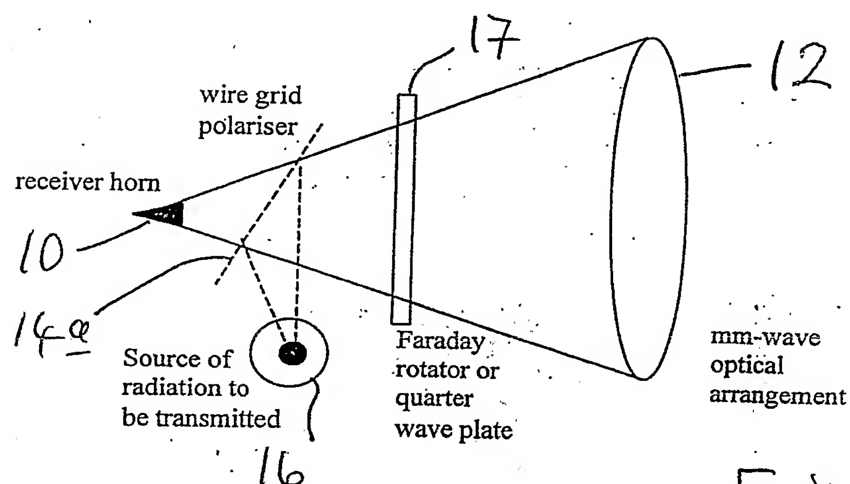
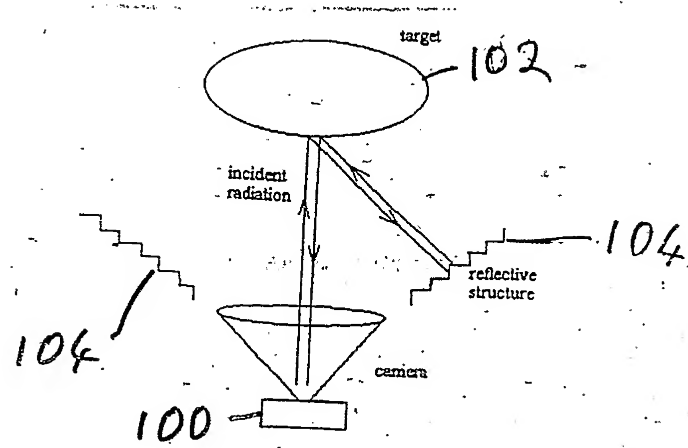


Figure 2



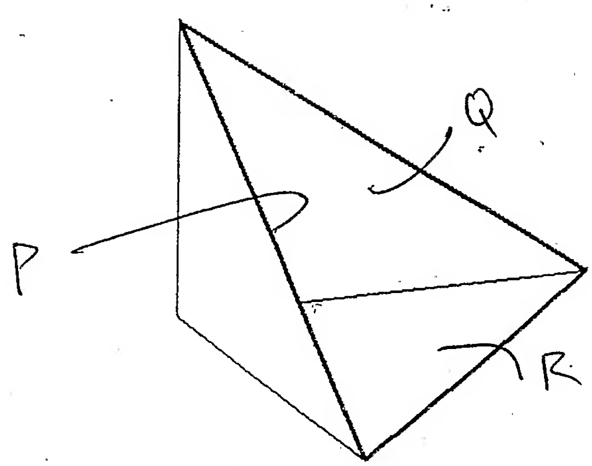


Figure 4

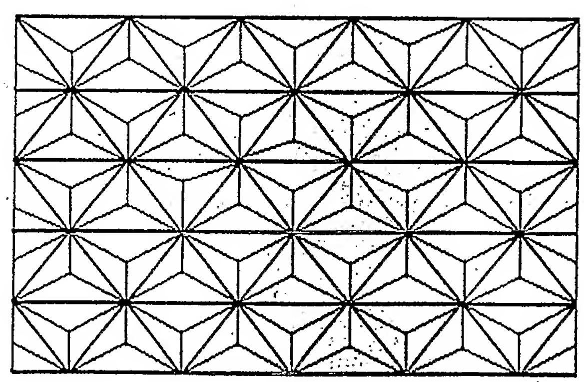


Figure 5